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NUCLEAR MEDICINE: PHYSICS AND INSTRUMENTATION SPECIAL FEATURE EDITORIAL

Innovation in nuclear medicine instrumentation: looking back and moving forward

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Motivated by the widespread commercial availability of hybrid SPECT/CT and PET/CT imaging and the challenges associated with the design and clinical adoption of hybrid SPECT/MRI and PET/MRI, we focus, in this special issue of BJR, on recent advances and future directions in nuclear medicine physics and instrumentation. During the last decade, tremendous efforts focused on addressing the challenges encountered in the conceptual design of PET/MRI systems as well as improving their quantitative performance to achieve similar performance compared with standard PET/CT systems. With the introduction of solid-state photodetectors, such as avalanche photodiodes (APDs) and silicon photomultipliers (SiPMs), the challenges of potential interference between PET and MRI components have now been to some extent sensibly addressed, thus paving the way toward compact fully integrated clinical PET/MRI systems with time-of-flight (TOF) capability. However, the technology is still in an embryonic state and its clinical role is yet to be established considering cost/benefit trafeoff. The number of scientific papers linked to the above topics has been expanding gradually, which spurred the compilation of comprehensive reviews in this special issue as a snapshot of the enthusiastically changing field of nuclear medicine technology.

The first paper in this special issue reviews the physical principles, technical developments in instrumentation and image reconstruction techniques that enabled the emergence of new clinical applications using SPECT/CT technology (Ljungberg and Pretorius, doi; http://dx.doi.org/10.1259/bjr.20160402).[1] This is followed by a comprehensive overview of the major technical innovations in PET/CT systems, focusing primarily on TOF-PET technology, dual-tracer imaging, inline hadron therapy dose imaging and yttrium-90 imaging in the context of resin and glass microsphere liver radioembolizations (Walrand et al, doi; http://dx.doi.org/10.1259/bjr.20160534).[2] Contrary to PET/CT, which was predominately developed since its inception for clinical imaging, combined PET/MRI technology was initially driven by research in the preclinical field for imaging laboratory animals in the mid-1990s. The bulk of PET/MR research to date focused on building MR-compatible PET detectors and readout technologies, addressing the challenges of MRI-guided PET attenuation correction and motion compensation, and also finding a niche or primary clinical role for PET/MRI (Cabello and Ziegler; doi http://dx.doi.org/10.1259/bjr.20160363).[3] Despite the widespread interest in PET/MRI instrumentation, systems capable of clinical simultaneous SPECT/MRI are not available yet to date. The challenges and ongoing efforts towards designing a dedicated prototype for clinical SPECT/MRI are discussed by Hutton et al (doi; http://dx.doi.org/10.1259/bjr.20160690).[4]

PET has, since its foundation, established itself as an important imaging modality enabling the quantitative assessment of molecular targets *in vivo*. PET quantification makes it possible to establish a link between the time-varying activity concentration in relevant organs/tissues and the fundamental parameters standing for the biological processes at the cellular level being assessed. The challenges associated with fully quantitative PET imaging is addressed in a detailed review focusing on recent efforts enabling not only to derive conventional PET metrics with higher accuracy but also to design novel protocols and data processing techniques enabling the generation of whole-body parametric images (Zaidi and Karakatsanis, https://doi.org/10.1259/bjr.20170508).[5]

There is no shortage of challenges and opportunities for the development of innovative nuclear medicine technologies and instrumentation. We hope that in this

limited space, we were able to give the readers of this issue a flavour of recent developments in the field and their potential applications in clinical and research settings in the future. The compilation of this special issue was truthfully gratifying and hope that the readers find the contents of value in their research.

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